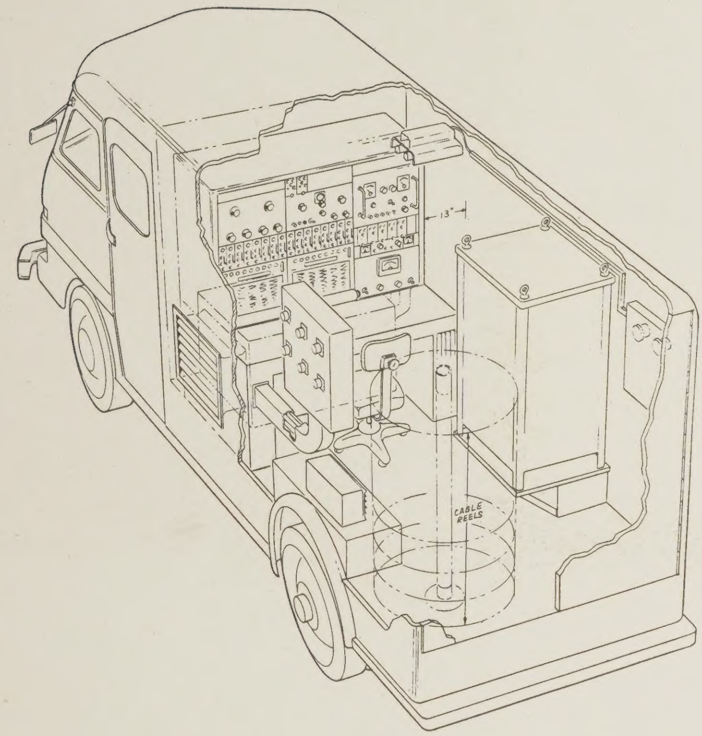



THE SIEGLER CORPORATION

HALLAMORE ELECTRONICS DIVISION

# PROPOSES A NOZZLE CONTROL UNIT CHECKOUT CONSOLE SYSTEM TO THIOKOL WASATCH DIVISION

1-1765-5896
5 June 1961

# TECHNICAL PROPOSAL TO
# THIOKOL CHEMICAL CORPORATION
# FOR
# NOZZLE CONTROL UNIT CHECKOUT CONSOLE SYSTEM

REFERENCE:

Request for Quotation 42125-AVM
1 April 1961

SUBMITTED BY:

HALLAMORE ELECTRONICS DIVISION
The Siegler Corporation
714 North Brookhurst Street; Anaheim, California

# FOREWORD

This proposal is submitted in response to Request for Quotation Number 42125-AVM from Thiokol Chemical Corp., Wasatch Division, Tremonton, Utah, dated 1 April 1961, for a Nozzle Control Unit Checkout Console System in accordance with Thiokol Specification EIS-8.

The following sections present our approach to the engineering, manufacture, testing, shipping, supervision of installation, customer training, and documentation requirements for one Nozzle Control Unit Checkout Console System.

# TABLE OF CONTENTS

# SECTION I
# DISCUSSION OF REQUIREMENTS

## 1.1 INTRODUCTION

The discussion of pertinent requirements contained in this section follow the general format of Thiokol Specification EIS-8, and form a part of our proposal. Those specifications requiring a more detailed coverage are discussed in later sections of this proposal.

(3. 1) Hallamore will conform with the intent of the latest applicable standards and codes in the design, fabrication, and wiring of all equipment.

(3. 3. 1.7) The FOB point will be the HED shipping dock, Anaheim, California.

The design of the NCU checkout console system van is such that it does not require additional packing for transit.

The proposed van, equipped, weighs 6000 pounds and is 20 feet long, 8 feet wide and 9 feet high.

Two rail facilities are available within five miles. The cost of shipment to Tremonton, Utah by rail including loading, tie down, protection (canvas cover) and unloading is approximately $650.00.

(3. 3. 2) An alternate proposal for manuals is discussed in paragraph (3. 10) below.

(3. 3. 3) The following exceptions have been discussed with, and approved by, Mr. Alan V. Manwaring of Thiokol:

— Programmer peak-to-peak output has been changed from 50 V to 30 V.

— 400 amp Power Supply is not to be tested with regard to reliability or accuracy.

(3.3.4) A cost analysis is submitted with this proposal. Spare parts information and pricing will be furnished to the buyer 30 days after award of contract.

(3.3.5) Major items of test equipment deemed necessary to maintain the NCU are:

| | |
|---|---|
| — 1 Oscilloscope, Model 120A (Hewlett-Packard) | $435.00 |
| — 1 VTVM, Model 631 (Triplett) | $ 59.50 |
| — 1 Eppley Standard Cell (MIN 7) (Bill Geist, Inc) | $ 36.00 |

The costs of test equipments are not included in this proposal.

(3.5.4) All system components will operate well within the manufacturer's specifications, and will meet reliability requirements listed in Thiokol Specification EIS-8. Transistors and semiconductors are used throughout the system wherever possible.

(3.5.4.1) Derating factors for semiconductor diodes, transistors, resistors, and capacitors will be in accord with Thiokol Specifications. All other components will be derated in accordance with good engineering practice to insure maximum reliability.

(3.5.5) Hallamore guarantees the work to be performed against defects of workmanship and materials, and that all equipments and accessories will be first-quality in every respect.

Hallamore agrees to repair or replace any defective part and correct any defective workmanship at their expense at Purchaser's request and without charge to the Purchaser at any time within one year following the Purchaser's acceptance of the work performed. All instruments furnished will be provided

with the manufacturer's guarantee for the particular instrument provided.

(3.5.6) Unless otherwise indicated, materials and equipment furnished will be standard products of manufacturers regularly engaged in the production of such articles.

(3.5.8) No substitution of equipment, components or parts will be made after contract award without prior approval of the responsible Thiokol engineer.

(3.6) Acceptance testing is discussed in Section II of this proposal.

(3.7) All drawings supplied by Hallamore will use the latest IRE established standards of symbolization, and will be clear and legible.

(3.7.2) No later than sixty (60) days after receipt of the purchase order, HED will furnish Thiokol with one reproducible sepia and four copies of approved preliminary drawings. These preliminary drawings will depict front panel and cabinet layout, input termination, design of all signal inputs, and all other information necessary for Thiokol to proceed with the design of the interface equipment, termination, etc. Additional information such as regulated and unregulated power requirements, air conditioning requirements, space and mounting requirements, system grounding requirements, etc. will also be furnished.

(3.7.3) Reproducible drawings will be submitted to Thiokol as the design work proceeds and as the design drawings are made ready for fabrication, prior to the start of fabrication for review, approval, retention and comment by Thiokol. After fabrication begins one each reproducible copy of the latest design drawings with annotations and design changes, etc., supplemental to the requirements of Thiokol will be submitted periodically to Thiokol for review and comment.

(3.8) Bi-weekly progress reports will be made to Thiokol for the complete period of the contract. These bi-weekly reports will verbally describe the status of the contract as of the reporting date and will include all information pertaining to the contract.

A progress schedule will be provided and submitted to Thiokol no later than the second Monday after award of the contract and conform to the Thiokol format. This schedule will be submitted as a reproducible copy and revision will be made as required.

HED will conform with all Inspection Progress Reports, Supplementary Schedules and discrepancy reports.

(3.10) Hallamore takes exception to all Handbook and PPB specifications referenced in Thiokol Specification EIS-8. We feel that the excessive costs required to produce handbooks to these specifications would not be justified by the questionable benefits gained by Thiokol if Hallamore were to fully comply with these requirements.

To produce such handbooks, all data, which now exists in the form of commercial vendor manuals, would have to be completely regenerated. This includes all drawings, photographs, tables, graphs, etc. Also adding to the cost is that vendors will not supply reproducible copies of proprietary manufacturing drawings or adequate handbook support data. Even if such items were obtainable, they would not meet the specification requirements. Therefore, Hallamore proposes an alternate approach which should more than satisfy Thiokol's documentation requirements --- and at a cost of less than one-tenth of that specified.

Hallamore will provide Thiokol with Operation and Service Manuals based on a system level. Basic contents will include:

— Functional System Description. This portion will describe pertinent functions and illustrate locations of each of the units comprising the system. Performance specification and power requirements, etc., will also be included.

— System Checkout Procedures. Adequate instructions will be provided to enable the operator to determine whether or not the system is functioning correctly.

— Operating Procedures. Descriptions of equipment connections, functions of operating controls and a detailed step-by-step system operating procedures will be included in this section.

— System Preventive Maintenance Routines.

— System block, wiring and cabling diagrams.

— Theory of operation*

— Troubleshooting procedures*

— Electrical Parts Lists*

*Hallamore will supply two sets of commercial vendor handbooks which adequately cover these pertinent subjects. Hallamore will propose similar instructions for all system components which we develop and manufacture for this program.

(3.11) HED will train at least two of the Thiokol technicians in the complete operation and maintenance of the equipment. These instructions will be provided at HED Anaheim during a regularly scheduled training school under qualified instruction.

HED will maintain a qualified person at Thiokol's plant site for a minimum of one (1) week to advise the technicians and operators in the proper operation

and maintenance of the Checkout System after final acceptance of the system. This person will be made available with one week's prior notice to HED.

(3.12) A list of recommended spare parts will be furnished to the buyer 30 days after contract award. Hallamore agrees to accept an order for any of the recommended spare parts within 60 days prior to delivery of the system.

(3.13) The services of a Field Service Engineer will be provided to supervise the installation of the system, at HED Anaheim, in the final system checkout. This Engineer will be thoroughly familiar with the system and all of its components prior to his arrival at the installation site. Before the system is accepted he will make or supervise any and all adjustments or alterations required to make the equipment operate in accordance with the specification. After final acceptance of the system, the Field Service Engineer will assist the Thiokol technicians in making changes as directed by the Thiokol Engineer to improve the overall system and to meet any added requirements. HED will submit estimates for extended Field Service Engineering contract, should such services be required by Thiokol after the normal installation and training period has been completed.

(3.14) Tag numbers and name plates will be designed and installed in accordance with Thiokol specifications.

(4.) A functional description and specifications of the system and major components appears in Section II of this proposal.

(4.2.8) Because all operating controls and instruments are located on front panels of rack mounted equipments, and are readily accessible to the operator, a separate console control panel is not required. Provisions for a manual

DC program voltage to the NCU in addition to the AC program will be incorporated.

(4.2.9) The mobile van is discussed in Section II of this proposal. It should be noted that the complete system is designed for portability over improved roads.

(4.3) Miscellaneous technical requirements are discussed in the following Sections of this proposal.

# SECTION II
# DESCRIPTION OF PROPOSED SYSTEM

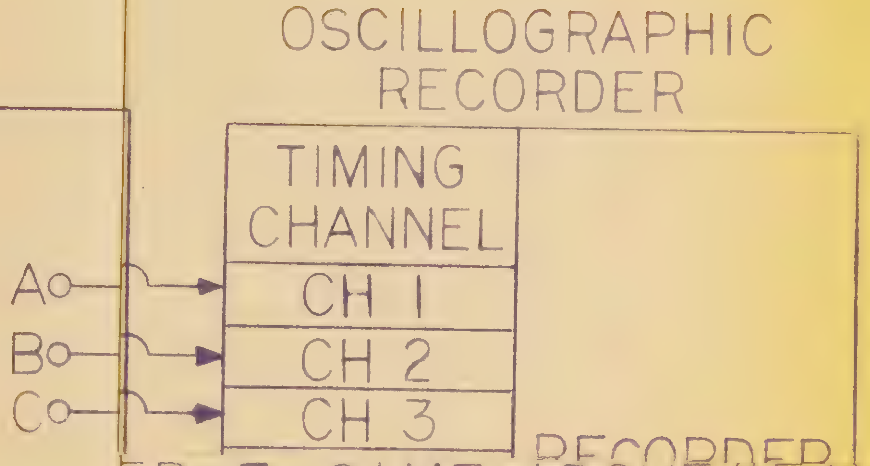
## 2.1 GENERAL DESCRIPTION

The Nozzle Control Unit Checkout Console System is used to functionally test a hydraulically operated nozzle control unit. In the application of the functional test, this system simulates all important input conditions to the NCU, compares all outputs against a set of predetermined standards and permanently records approximately 16 test parameters. The mechanization of these functions constitute the complete test system. Figure 2-1 is a block diagram of the proposed NCU Checkout Console System which performs all of these functions, figure 2-2 is a list of major components, and figure 2-3 shows a general physical configuration of equipments within a van. The van is a Dodge P-300 cab and chassis with a 12-foot Boyertown body having a payload space 20 feet long, 8 feet wide, 9 feet high; approximately 420 cubic feet volume.

Air conditioning is provided by a 3-ton Keco Model F6B-CE unit installed under the console. Conditioned air is ducted to cool rack mounted equipment, and is also ducted into a diffusing chamber located in the console leg for operating personnel comfort. Heating is provided by means of a thermostatically-controlled electric heater mounted on the van wall.

All units, with the exception of the 400 amp VDC Power Supply are mounted in a desk-type console rack. The 400 amp VDC Power Supply and a cable reel are mounted at the rear of the van as shown in figure 2-3.

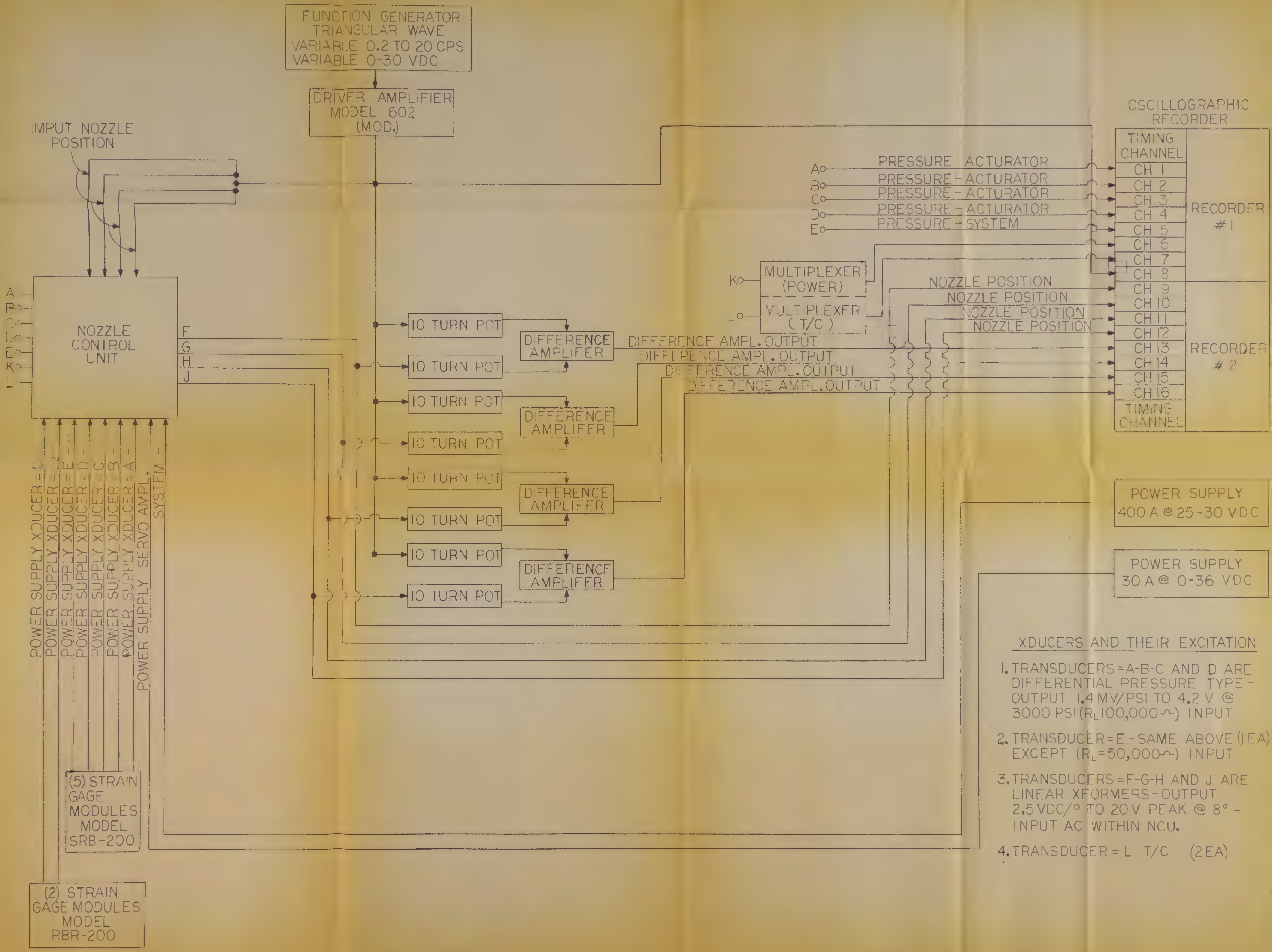
Instrument racks are equipped with grounding strips of solid copper with dimensions of 3 inches by 4-1/4 inches by 24 inches rack depth. System




ER=E - SAME ABOVE (1 EA)
$R_L$=50,000Ω) INPUT

ERS=F-G-H AND J ARE
ORMERS-OUTPUT
TO 20 V PEAK @ 8° -
WITHIN NCU.

ER = L T/C (2 EA)




XDUCERS AND THEIR EXCITATION

1. TRANSDUCERS = A-B-C AND D ARE DIFFERENTIAL PRESSURE TYPE - OUTPUT 1.4 MV/PSI TO 4.2 V @ 3000 PSI ($R_L$ 100,000 Ω) INPUT
2. TRANSDUCER = E - SAME ABOVE (1 EA) EXCEPT ($R_L$ = 50,000 Ω) INPUT
3. TRANSDUCERS = F-G-H AND J ARE LINEAR XFORMERS - OUTPUT 2.5 VDC/° TO 20 V PEAK @ 8° - INPUT AC WITHIN NCU.
4. TRANSDUCER = L T/C (2 EA)

| UNIT | MODEL | TOTAL PRICE | UNIT POWER | UNIT WEIGHT | UNIT DIMENSIONS |
|---|---|---|---|---|---|
| (1) Mobile Van | L.D. Coffing Co., Santa Ana Dodge P-300 Cab and Chassis | $3900.00 | | 6000 | |
| (1) Air Conditioner | Keco Model F6B-CE | $2800.00 | 36,000 BTU/Hr. 440V | 730 | 34x46x26 |
| (1) Power Supply | Christie Electric Corp. 2C36-400KX4S 400 Amp @ 25-30 VDC | $2782.50 | 42A @ 60 cycles 3Ø, 440V | 750 | 26-1/4x31-1/2x52 |
| (1) Power Supply | Electronic Instruments TO-36-30M (for ± 0.01% Load) 30 Amp @ 0-36 VDC | $1300.00 | 115V, 60 cycles, 1930 | 137 | 15-3/4x19x16-1/2 |
| (1) Function Generator | Hewlett-Packard HP-202AR (modified) | $ 635.00 | 115V ± 10%, 60 cps, 175 W | 36 | 19x10-1/2x13 |
| (1) Multiplexer | Industrial Timer Corp. Series MC1 with E-12 Gear Rack | $ 110.00 | 115V ± 10%, 60 cps, 8.5W | 2 | 2x2x12 |
| (5) Strain Gage Module | Video Instruments Model SRB-200, 0-30VDC, 0-200 MA | $1130.00 | 110V ± 10%, 60 cps | 4 | 4.6x2.7x12.1 |
| (1) Meter Monitor Panel | Video Instruments Model ENO-N (modified ENO-2 to read 0-30 VDC EXC.) | $ 895.00 | 115V ± 10%, 60 cps | 15 | 3.5x19x12 |
| (1) Driver Amplifier | Video Instruments Model 602 (modified) 0-30 VDC, 100MA | $ 600.00 | 115V ± 10%, 60 cps | 2 | 2.5x7x8 |

Figure 2-2. Major Components

| UNIT | MODEL | TOTAL PRICE | UNIT POWER | UNIT WEIGHT | UNIT DIMENSIONS |
|---|---|---|---|---|---|
| (2) Strain Gage Module | Video Instruments Model RBR-200 (T/C Balance & Cal. Unit) | $ 350.00 | 110V, ± 10%, 60 cps | 2 | 4.6x5.4x12.1 |
| (2) Recorder | Sanborn Model 958-5485 Eight-Channel System, Less Cabinets | $12910.00 | 115V, ± 10%, 60 cps, 550W | 590 | 19x25-1/4x18 |
| (1) System Calibrator | Hallamore Electronics Consisting of: 1 Power Supply (Video Instruments) SR 200 EM, 0-30V, 0-200 MA 12 Precision Resistors 0.5 W 0.1% | $ 150.00 | 115V, ± 10%, 60 cps | 2 | 4x3x12.13 |

Figure 2-2. Major Components (page 2)

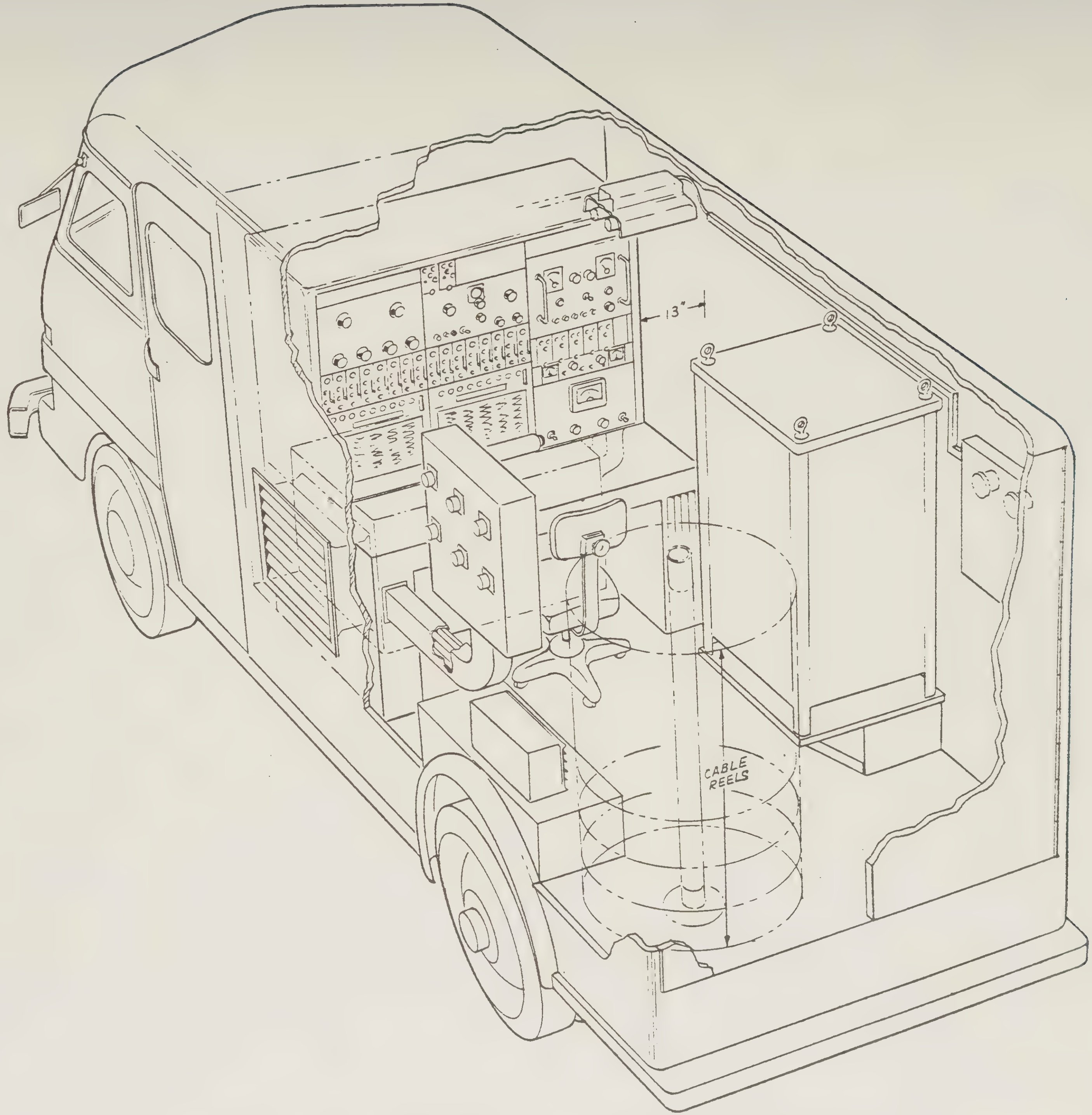



Figure 2-3. NCU Checkout Console System, Mobile Van

grounds are tied to these grounds which are parallel connected to the local ground.

All power and switching circuits incorporate interlocks to prevent damage to equipment through accidental power failure or operator error.

A cable connector panel is installed on each side of the van as illustrated in figure 2-3. All internal cabling is routed through ducting to equipment.

Interior lighting consists of two 6-volt dome lights and one fluorescent fixture mounted above the console desk. Tie-down fixtures are provided for the chair and miscellaneous articles. A plugmold is installed along the van wall for convenience outlets.

The Programmer provides the required signal to drive the four Nozzle Actuator Servos via a common line. A driver amplifier is provided for signal conditioning and impedance matching. The output of this amplifier is fed directly to the Nozzle Actuator Servos and to Channel #8 of the recorder for monitoring. Provision has been made to substitute Programmer input with manually adjustable DC drive from the system calibrator power supply. The function generator or DC Voltage signal will also be fed through four 10-turn helical precision potentiometers for signal conditioning to the four differential amplifiers, where it will be compared with the output signals from the four nozzle position linear transformers. The difference, if any, between these will be recorded. Channels 13 through 16 of the number two recorder will be utilized to display this data.

The output signals from the nozzle position linear transformer also will be fed through 10 turn helical precision pots for signal conditioning and recorded directly on channels 9 through 12. Provisions are made to switch off the signals to and from the nozzle position actuators and switch on the calibrating

circuitry and equipment is provided to calibrate the programmer output, differential amplifiers and recorder.

The NCU outputs from the main hydraulic system pressure transducer and the four actuator or differential pressure transducers is fed directly to the recorder channels 1 through 5. Equipment is supplied for bridge balance and calibration points for each individual transducer and channel. A multiplexer will be provided to sample both NCU thermocouple outputs and record on channel 11. Sampling time will be one second per thermocouple. These two thermocouple outputs will also be provided with bridge balance and calibrating points.

The four monitor channels of system operating voltages will be fed to the same multiplexer with a sampling time of one second per channel and recorded on channel 10.

A voltage monitor will be provided to measure or compare all signals used in the console.

Specifications on the proposed equipment are listed in paragraph 2.3.

## 2.2 FUNCTIONAL DESCRIPTION

### A. Programmer Section

A function generator (HP-202AR) with its associated driver amplifier provides the programmed triangular wave excitation to drive the four NCU servo actuator systems (via a common line); four difference amplifiers (Sanborn Model 958-3400) for comparing with the output of four nozzle position linear transformers; and to an oscillograph recorder (Sanborn Model 958-5484) channel for direct recording. A three-position switch is provided for the selection of calibration, DC excitation, or AC excitation. The switch, when placed in the "CAL" position, connects the output of the system's calibrator to the oscillograph recorder.

The four discreet calibration voltages of the system calibrator are recorded and utilized as reference for reduction of the transducer data. The system calibrator is adjusted and checked for accuracy by the use of the meter monitor panel. The DC position connects the output of the system calibrator into the system such that it provides DC excitation (four discreet steps) to the four NCU servo actuators, recorder, and to the difference channels. The switch, when in the AC position, connects the output of the function generator and associated drive amplifier into the system such to provide an AC signal excitation, which can be programmed both frequency and amplitude wise, to the four NCU servo actuator, recorder and difference channels.

Calibration

The three position switch is placed in the "CAL" position and the system calibration switch to the 100% calibration position. The meter monitor panel switch is placed in the "MON" position and adjusted for 30 VDC. If meter monitor panel does not indicate balance, adjustment is made to the system calibrator power supply until balance is obtained. The meter monitor panel switch is placed in the "OUT" position and the oscillograph recorder channel is adjusted for the desired pen deflection. The system calibrator is then stepped through the four point calibration positions (100%, 75%, 50% and 25%) and checked with the oscillograph recorder pen position. The three position switch is then placed in the "AC" position and the function generator's output is then adjusted for the desired level utilizing the previously recorded "DC" calibration data. Frequency is selectable by means of the frequency dial knob of the function generator.

This completes the setup and calibration of the Programmer section of the NCU Checkout Console System.

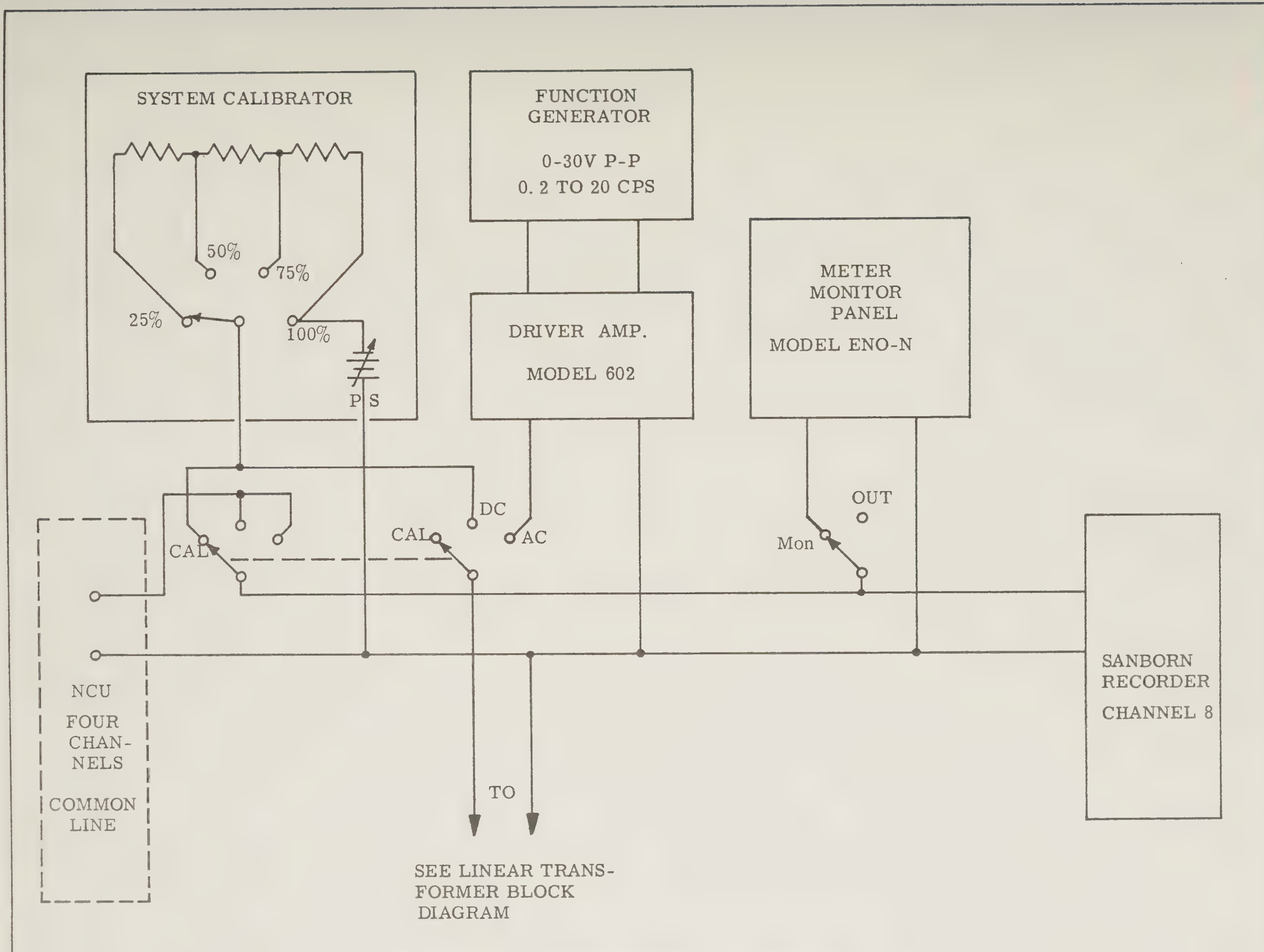



Figure 2-4. Programmer Section Block Diagram

B. Linear Transformers (Nozzle Position)

The four linear transformer outputs are fed through a ten turn precision potentiometer to four oscillograph channels and four difference DC amplifiers (Sanborn Model 958-3400). The Programmer (Hewlett-Packard Model 200A) is fed through the drive amplifier (Video Instruments Model 602), through a ten turn precision potentiometer to each of the four difference DC amplifiers. The difference DC amplifiers present the difference signals between the output of the individual linear transformers and the programmed input signals to the NCU. A system calibrator provides for four (4) point calibration of the eight channels of oscillograph recorded information. The system calibrator has a five position switch for the selection of four calibration points. When calibrating the system, the meter monitor panel (Video Instruments Model ENO-N) is utilized for precision adjustment of the system calibrator excitation power supply and precision adjustment of each ten-turn precision potentiometer. The four linear transformer channels are prepared for system operation by means of calibration.

Calibration

The system calibrator output is applied to the output of the linear transformer by means of a five (5) position switch and adjusted excitation power supply to a value representing full nozzle deflection by balancing the meter monitor panel. The same voltage value is applied through the programmer. The difference voltage of zero VDC being applied to the two inputs of the difference amplifier can be adjusted to equal potential by means of the ten-turn precision potentiometers on the output of the linear transformer and the programmer while observing oscillograph recorder pen deflection on the appropriate channel. This adjustment will determine the zero data line on the oscillograph recorder.

Maximum record levels of the direct record channels from the linear transformers are adjusted with the system calibrator set at the value described above. Selection on the calibrator switch of the 75%, 50% and 25% levels will complete calibration.

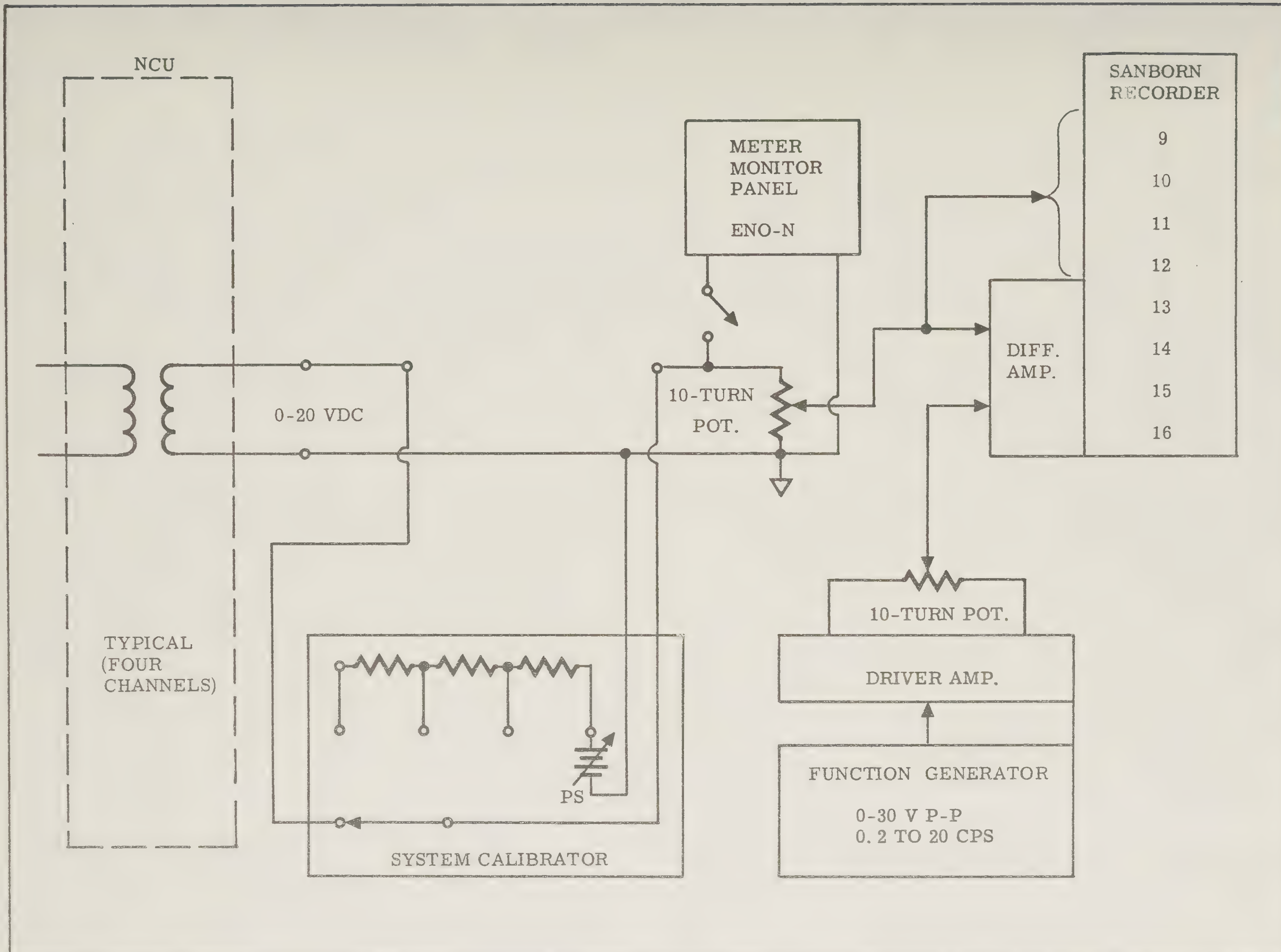



Figure 2-5 Linear Transformers (Nozzle Position)

C. Differential Transformers

Five differential transformers are each fed to a strain gage module (Video Instruments Inc. Model SRB-200) for bridge balance and calibration. Each differential transformer channel is then fed to one of the five oscillograph recording channels for recording. The strain gage module consists of an excitation power supply, four precision calibrating resistors (selection by means of a selector switch at the front of the unit and connected to the calibrating circuit by means of a push button) and a precision potentiometer for zero balance. The meter monitor panel (Video Instruments Inc. Model ENO-N) is utilized to check the accuracy of bridge balance and calibration. Bridge balance and calibration is completed when the oscillograph recorder pen adjustment is made for zero maximum deflection and completion of the four point calibration.

Bridge Balance

A lever type switch with a center-off position is used to select the monitoring voltage. When pushed to the right, the excitation voltage is fed to the meter monitor panel for balance, and if out-of-balance, the potentiometer is then adjusted for balance. The oscillograph recorder pen is adjusted for zero setting. The lever type switch is then pushed to the left. The excitation voltage is fed to the meter monitor panel for balance and the oscillograph recorder pen is adjusted for maximum deflection which then completes the bridge balance.

Calibration

The calibration resistors (4 point calibration) are selected by means of a selector switch at the front of the strain gage modules and are fed to the meter monitor panel and the oscillograph recorder for accuracy check. At the completion of the four point calibration for all five system pressure strain gage modules, the system is then ready for operation.

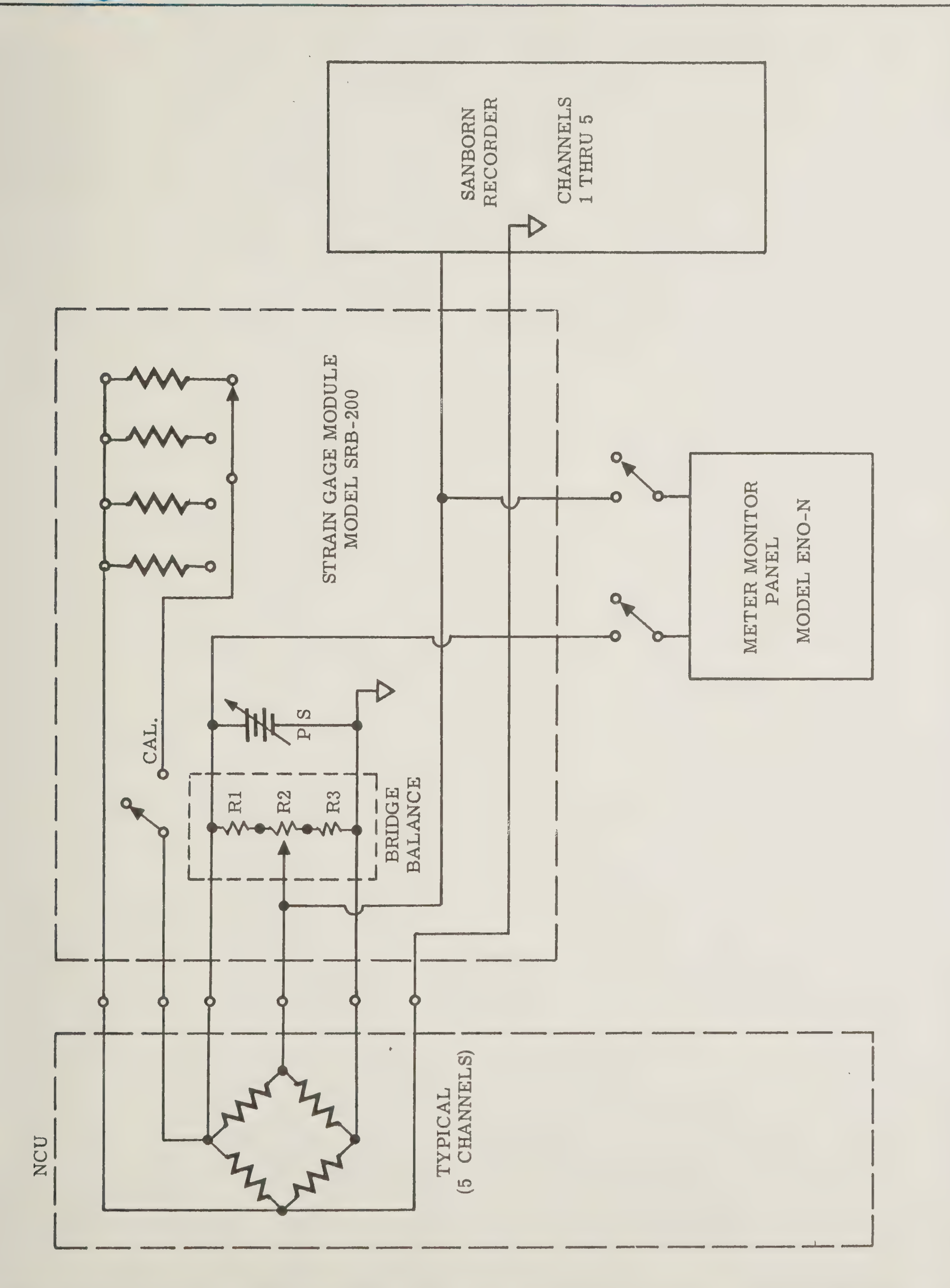



Figure 2-6. Differential Transformer

D. System Temperature

Two channels of thermocouple information (system temperature) are each fed to a signal conditioning module (Video Instruments Co., Model RBR-200) which provides excitation voltage, a means of balancing and a method for calibrating a resistance bulb. The value of resistors in the bridge network are so selected to equal the resistance of the thermocouple at the desired low temperature and the desired high temperature extreme. A four-position selector switch on the signal conditioning module will select the one leg of the bridge for bridge balance and four point calibration. The two channels of thermocouple information are then fed to the multiplexer (Industrial Timer Caps Model MC1-E12) which samples each channel of thermocouple signal for 750 MIL SEC at the rate of one sample per second. The multiplexer output is then fed to a channel of the oscillograph recorder. Identification of one block (2 samples) will be indicated by a spike at the beginning of the first sample. A four position switch will be provided for checking the accuracy of system calibration and bridge balance. This switch will select the input to the meter monitor panel (Video Instruments Inc., Model ENO-N).

Bridge Balance

Each thermocouple channel of information is balanced independently. The output of the signal conditioning module excitation power supply is fed to the meter monitor panel where it is calibrated for 30 VDC by means of the balance meter and if out of balance, the excitation power supply is adjusted for balance. For transducer balance the value of R4 is selected to equal the resistance of the resistance bulb at the desired low temperature extreme. With the monitor held in position 4, the zero control R5 should be set for zero electtrical output. The value of R1, R2 and R3 are chosen so that the sum of R1 through R4 equals the resistance of the bulb (and also for four point calibration) at the desired high temperature extreme, with the strain gage monitor held in position 1.

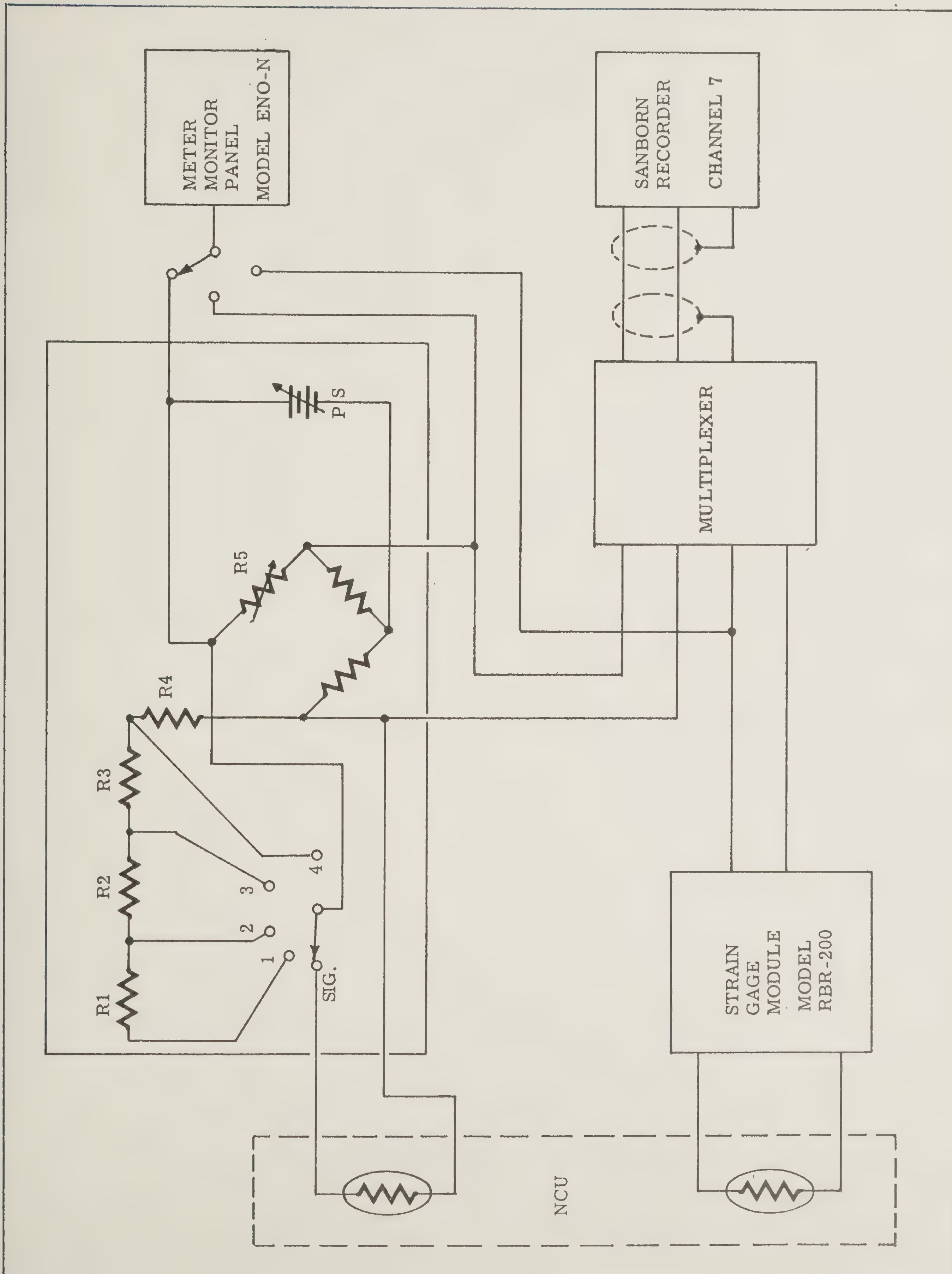



Figure 2-7. System Temperature

Calibration

The signal conditioning module selector switch is placed in position #1 and the oscillograph recorder pen is adjusted for the desired maximum pen deflection. The switch is then placed stepped through the four points of calibration and checked with the oscillograph recorder pen position. While stepping through the four point calibration the meter monitor panel checks the accuracy of the bridge balance adjustments.

This completes the setup bridge balance and calibration of this section of the NCU checkout console system.

E. System Operating Voltage

The four system operating voltages (0-28 VDC) are fed to a multiplexer (Industrial Timer Corp Model MC1-E12) which samples each system operating voltage for 750 MIL SEC at the rate of one sample per second. The multiplexed output is then fed to a channel of the oscillograph recorder. Identification of one block (4 samples) will be indicated by a spike at the beginning of the first sample. A five position switch will be provided for means of monitoring the four system operating voltages. Monitoring will be accomplished by selection of switch positions which will correspond to one of the four system operating voltages. The system operating voltage will then be fed to the meter monitor panel (Video Instruments Inc. Model ENO-N) for monitoring. A two position switch will also be provided for the calibration of the oscillograph recorder channel. This switch will select calibration or multiplexer input to the oscillograph recorder channel.

Calibration

The "CAL"-"SIGNAL" switch is placed in the "CAL" position and the system calibrator switch placed in the 100% position. The oscillograph recorder channel is adjusted for the desired pen deflection. The system calibrator is then stepped through the remaining three of the four point calibration positions

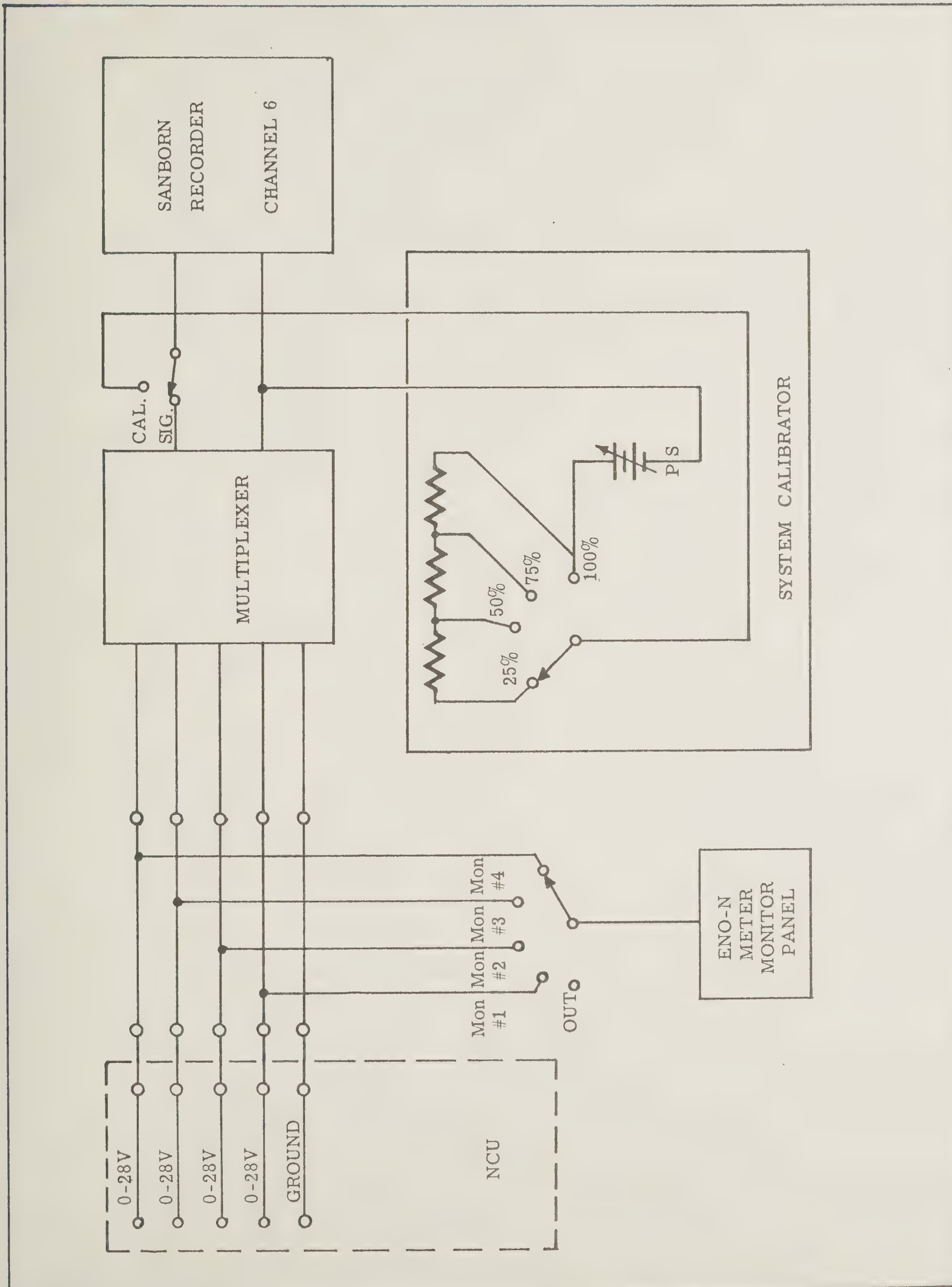



Figure 2-8 System Operating Voltage

(100%, 75%, 50% and 25%) and checked with the oscillograph recorder pen position. The "CAL"-"SIGNAL" switch is returned to the "SIGNAL" position, which completes the setup and calibration of this section of the NCU checkout console system.

## 2.3 ERROR ANALYSIS

The error analysis presented herein is illustrative of the expected system accuracy. Each section and/or channel has been evaluated, considering component makeup, as to its % accuracy. After review of Thiokol's format for determination of repeatability and accuracy, Hallamore elected to present, at this time, their error analysis as the RMS value; that is $\sigma = (\Sigma\ \sigma \text{ components})^{1/2}$. This is due to the fact that certain measured values of the completed system, i.e., $X_V$ are unobtainable until the components are assembled as a complete system. Hallamore is prepared to submit as part of the acceptance test, a calculation of the overall system accuracy utilizing Thiokol's format.

### ERROR ANALYSIS

| Component | Accuracy |
|---|---|
| Sanborn Recorder | ± 1.5% |
| System Operating Voltage Calibrator | ± 0.15% |
| Multiplexer | ± 0.5% |
| Strain Gage Module | ± 0.1% |
| Thermocouple Module | ± 0.1% |
| Meter Monitor Panel | ± 0.1% |
| Driver Amplifier | ± 0.1% |
| Function Generator | ± 1.0% |
| 10-Turn Potentiometer | ± 0.1% |


$$\sigma_{RMS} = \sqrt[2]{(0.1)^2 + (0.1)^2 + (1.5)^2}$$

$$= 1.51\%$$

DIFFERENTIAL TRANSFORMER


$$\sigma_{RMS} = \sqrt[2]{(0.5)^2 + (0.15)^2 + (0.1)^2 + (1.5)^2}$$

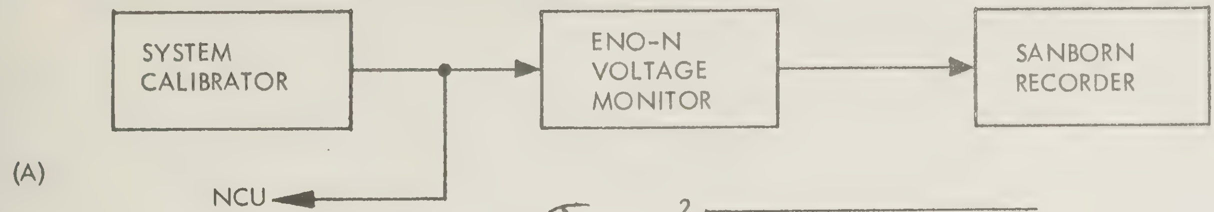
$$= 1.59\%$$

SYSTEM OPERATING VOLTAGE

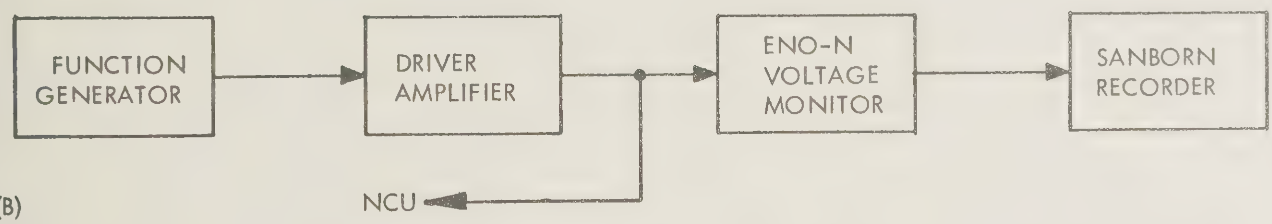

$$\sigma_{RMS} = \sqrt[2]{(0.1)^2 + (0.1)^2 + (0.5)^2 + (1.5)^2}$$

$$= 1.59\%$$

THERMISTER

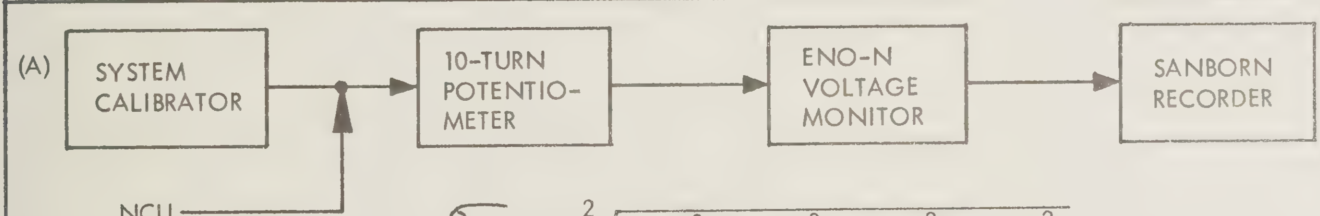



$$\sigma_{RMS} = \sqrt[2]{(0.15)^2 + (0.1)^2 + (1.5)^2}$$
$$= 1.51\%$$

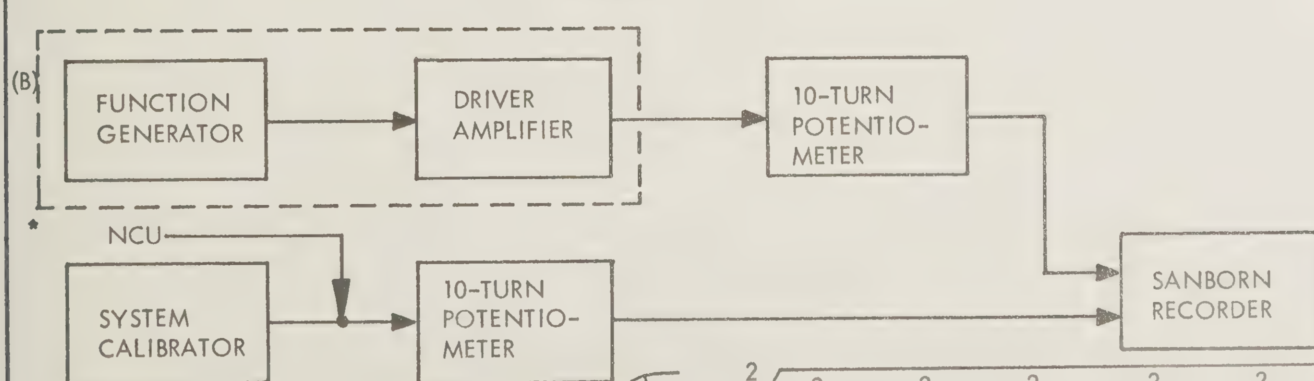



$$\sigma_{RMS} = \sqrt[2]{(1)^2 + (0.1)^2 + (0.1)^2 + (1.5)^2}$$
$$= 1.81\%$$

SERVO ACTUATOR DRIVE




$$\sigma_{RMS} = \sqrt[2]{(0.15)^2 + (0.1)^2 + (0.1)^2 + (1.5)^2}$$
$$= 1.51\%$$




$$\sigma_{RMS} = \sqrt[2]{(1)^2 + (0.1)^2 + (0.1)^2 + (0.15)^2 + (0.1)^2 + (1.5)^2}$$
$$= 3.3025 = 1.82\%$$

*MANUALLY ADJUSTED DC VOLTAGE MAY BE SUBSTITUTED.

LINEAR TRANSFORMER

When components are arranged linearly to form a system, accuracy of the system may be found as follows:

$$\sigma_{RMS} = \sqrt[2]{\Sigma\, \sigma_{comp.}^{2}}$$

This is based on the probability that the error of the components forming the system do not fall in the same direction, either plus or minus, and would be determined by the RMS. The error analysis as presented here excludes the transducers, etc. of the nozzle control unit.

## 2.4 MAJOR COMPONENT SPECIFICATIONS

A. Mobile Van, Dodge P-300 Cab and Chassis

12 foot Merchandiser with a Boyerton Body. Interior payload space measuring 144 inches long by 74 inches wide by 72 inches at roof center and 71 inches at side walls. The body is mounted on a forward control chassis having an approximate wheelbase length of 137 inches.

Engine - 6 cylinder, slant, 140 hp

Doors - 74 inch wide rear

Springs - 1500 lb. cap. - front
- 2050 lb. cap. - rear

Tires - 8-19-5, 8 ply
- spare wheel

G.V.W. - 8,000 lbs.

Body and Payload Allowance - 5090 pounds

The van will also be provided with marker lights, directional lights, electric wipers, stop and tail lights and will be painted as specified.

B. Air Conditioner - Keco Model F6B-CE

Type - Self-contained, air cooled, electric motor driven, for cooling, filtering, dehumidifying and ventilating air for vans or shelters. Twin unit refrigeration system.

Cooling Capacity - three-ton range

Size - 34 inches deep, 46 inches wide, 26 inches high

Controls - Unit mounted

Power - 440 VAC, 3-phase

Weight - 730 pounds

C. T/L Control and Calibration Unit - Video Instruments Model RBR-200

The RBR-200 T/L Control unit contains a solid state regulated power supply for excitation voltage and provides a method for calibrating and a means of balancing a resistance bulb.

Voltage Range (modified) - 0 to 30 VDC

Current Range - 0 to 200 MA

Output Impedance - Less than 0.1 ohm

Load Regulation - Better than 0.1% with changes from no load to full load.

Line Regulation - Better than 0.1% with changes from 95 to 135 volts

Output - Floating

Noise and Hum to Ground - Less than 10 microvolts peak-to-peak when measured with a 350 ohm strain gage bridge.

Leakage Resistance - At least 10,000 megohms

Temperature Stability - Better than 0.0005% per degree F.

Ambient Temperature Range - Plus 40°F to plus 120°F

Supply Voltage - 95 to 135 volts, 60 cps

D. Meter Monitor Panel - Video Instruments Model ENO-N

The ENO-N Meter Monitor Panel provides an accurate means for reading strain gage excitation and signal voltage. Adjustment of excitation voltage may be

made to 0.1% accuracy, and balance to within $\pm$ 10 microvolts of true zero. An unknown voltage (0-30 VDC) can be measured as follows: A portion of a stable reference voltage is selected and adjusted to a predetermined value by a digital readout dial on a precision, 10 turn helical potentiometer. The difference between the reference and unknown voltage is amplified by a DC amplifier, requiring only 10 mv to give a full scale deflection on the meter. The sensitivity of the meter is multiplied by the gain of the amplifier and the meter movement is protected from overload signals by limited amplifier output. When the reference and unknown voltages are equal, the meter will give a "null" indication.

The balance meter has a full scale sensitivity of 300 microvolts through a DC amplifier. To obtain a null balance on an unstressed gage, the balance control must be adjusted until the meter indicates a null, with the digital readout dial set at 000. Using the balance meter and a reference standard cell provides a means of accurate calibration of the whole voltage monitor meter.

E. Stavolt Power Supply - Christie Model 2C-36-400KX4S

Stationary style, to be equipped with a timer capable of being set for 3 minutes to turn unit off, and provisions are to be made for remote On-Off control.

DC Voltage Range - 26-36 VDC

DC Amp. Continuous - 400

Static Regulation Accuracy - $\pm$ 0.25%

Dynamic Regulation (Overshoot and Undershoot)

1/2 load - 4 V
Full Load - 8 V

Voltage Ripple - 1% RMS

Recovery Time, F.L. to N.L. or N.L. to F.L. - 50 milliseconds

AC Amp at 440 V - 42

Net Weight - 750 pounds

F. Power Supply - Electronic Instruments Model TO36-30M

DC Output - 0-36 volts
0-30 amps

Input Power Required at F.L. - 125 VAC, 60 CPS - 1930 watts

Transient Response (N.L. to F.L. or F.L. to N.L.) Output Recovers to within - 150 millivolts
100 (in) microseconds

Ripple - Less than 0.001 volts RMS

Regulation - 0.01% load and 0.3% line

Output Impedance - 0.001 ohm @ 1 KC up to 0.2 ohm @ 100 KC

Circuit Protection - Electronic and electromagnetic circuit breaker in DC output, fuse in AC line input

Input Power - 105-125 VAC, 50-60 CPS, single phase

Meters - DC amperes and DC volts

Dimensions - 15-3/4 inches panel height
19 inches panel width
16-1/2 inches panel depth

Weight - 137 pounds

G. Function Generator - Hewlett-Packard Model 202AR

The instrument is continuously variable through 5 bands covering all frequencies from 0.008 cps to 1200 cps. It offers exceptional stability and distortion of less than 1% over most of the band. Any of three desired waveforms - sine, square or triangular - may be instantly selected by a front panel switch. Output is high - 30 volts peak-to-peak - for all three waveforms and is essentially constant over the entire frequency range.

Frequency Range - 0.008 to 1200 cps in fine decade ranges

Dial Accuracy - 2% from 1.2 to 12; 3% from 0.8 to 1.2

Frequency Stability - Within 1% including warm-up drift

Output Waveforms - Sinusoidal, square and triangular

Maximum Output Voltage - 30 volts peak-to-peak across rates load (4,000 ohms) for all three waveforms.

Internal Impedance - Approx. 40 ohms over the entire range

Output System - Output is isolated from ground and either side may be grounded. Output system is direct coupled; DC level of output remains stable over long periods of time and can be adjusted to zero by a front panel control.

Frequency Response - Constant within 0.2 db

Hum Level - Less than 0.01% of maximum output

Sync Pulse - 10 volts peak negative, less than 5 microseconds duration. Sync pulse occurs at crest of sine and triangular wave output.

Power - 115/230V $\pm$ 10%, 50/1000 CPS, 175 watts

Dimensions - Rack mount, 19 inches wide, 10-1/2 inches high, 13 inches deep

Weight - 36 pounds

H. Strain Gage Module - Video Instruments Co. Model SRB-200

The SRB-200 Strain Gage Module combines a solid state regulated power supply with strain gage balance and calibration circuits. The isolated power supply can operate as a constant voltage type or a constant current type. The calibration circuitry utilizes a 6-wire system to provide close calibration accuracy. The balance circuitry has a wide enough range to balance a variety of transducers.

Voltage Range (modified) - 0 to 30 VDC

Current Range - 0 to 200 milliamperes

Output Impedance - Less than 0.1 ohm

Load Regulation - Better than 0.1% with changes from no load to full load.

Line Regulation - Better than 0.1% with changes from 95 to 135 volts

Output - Floating

Noise and Hum to Ground - Less than 10 microvolts peak-to-peak when measured with a 350 ohm Strain Gage Bridge

Leakage Resistance - At least 10,000 megohms

Temperature Stability - Better than 0.0005% per degree F

Ambient Temperature Range - +40°F to +120°F

Supply Voltage - 95 to 135 volts, 60 cps

I. DC Amplifier - Video Instrument Co. Model 602 (modified)

Input - Differential isolated from output and ground

Input Impedance - 100,000 ohms minimum

Signal Source Impedance - 500 ohms

Common Mode Rejection - $1 \times 10^8$: 1 at dc at least
$1 \times 10^6$: 1 for all dc common mode signals up to 60 cps having amplitudes of $\pm$ 200 volts peak, and with an unbalance of 10,000 ohms maximum in either input lead (above conditions met with ground shield connected)

Gain - Fixed at 10

Gain Stability - 0.1% for 24 hours

DC Linearity - $\pm$ 0.1% of full scale output (10V) with a load impedance of 50 ohms or more

Noise - 4 microvolts RMS referred to the input at 100 cps bandwidth

Zero Stability - Better than 0.05% of full scale output for 1000 hours

Output - Single ended, isolated from input and ground, 100 mv max.

Output Voltage - 30 VDC peak-to-peak

DC Output Impedance - Less than 0.5 ohms

Output Ripple - Less than 10 mv RMS

Maximum Capacitive Loading - 10 microfarads at 100 cps; more at lower bandwidth

Bandwidth - $\pm$ 1.0% DC to 10 cps; less than 3 db down at 100 cps.

Integral Regulated Power Supply - Requires 115 V $\pm$ 10 volts, 50-400 cps

Operating Temperature - +60°F to +120°F

J. Oscillograph Recorder - Sanborn Model 958-5485

The Model 958-5485 consists of:

One (1) 1958-180 Recorder Assembly

One (1) 958-3400 Medium Gain DC Amplifier

One (1) 858-1100-C4 Power Panel

One (1) 858-1100-C7 Signal Cable

One (1) 358-1100-C25 Amplifier Support Guide

The recorder assembly, an eight channel recorder, includes a flush-front recorder and a transfer chassis. The recorder features 9 pushbutton controlled chart speeds; individual stylus heat controls; provision for remote control of chart drive, chart speeds, timer and marker; built-in paper take-up and paper footage indicator; approximately 8 inches of visible record; rigged enclosed galvanometers for lasting service; permanent accurate inkless recordings in true rectangular coordinates; and velocity feedback damping for greater accuracy by insuring galvanometer damping at all times.

The amplifier assemblies are transistorized and consist of 8 channels of amplification and a common power supply. Each channel is complete from signal input terminals to galvanometer output terminals. Each channel of amplification consists of a front-end modulator and input transformer assembly, a high gain carrier amplifier, a demodulator and filter, and a drive amplifier. The transistorized modulator is operated at 1200 cps. A common power supply at rear of amplifier supplies power for all channels. The amplifier has the following controls: Range, Gain, Function (Use V/10 div, Use MV/div, Zero and Cal.), Position and Galvanometer Frequency Compensation.

Model 958-5485 Specifications:

Sensitivity - 0.5, 1, 2, 5, 10 and 20 mv/div and volts/div .

Input Resistance - 1/2 megohms on mv ranges , 1 megohm on volt ranges. Input is floating and guarded.

Common Mode Voltage - $\pm$ 500 volts maximum

Common Mode Rejection - 140 db mininum, DC
120 db minimum at 60 cps with no unbalance
100 db minimum at 60 cps with 5000 ohms unbalance.

Drift - 1/4 div max. as a function of 10°C ambient temperature change to 50°C; 1/10 div max. as a function of line voltage variation from 103 to 127 volts.

Gain Stability - Better than 1% to 50°C; better than 1% for line voltage variation from 103 to 127 volts

Frequency Response - 0 to 150 cps within 3 db at 10 div peak-to-peak, with 3 inch stylus; 0 to 125 cps within 3 db at 10 div peak-to-peak with 4 inch stylus.

Response Time - 4 milliseconds, 10% to 90% with 3 inch stylus; 5 milliseconds with 4 inch stylus, 4% or less overshoot

Noise - 1/4 div peak -to-peak maximum

Calibration - 10 millivolts internal $\pm$ 1%

Attenuator Error - $\pm$ 2% maximum

Power Requirements - 115 volts $\pm$ 10%, 60 cps, 550 watts

K. Multiplexer - Industrial Timer Corp. Model MC1-E12

The Multiplexer unit is a multi cam timer and switch assembly. The cams are mounted on a single drive shaft, coupled to a motor by a gear and rack assembly. Each cam is independently adjustable for 2% to 98% of the total time cycle. The cams can be adjusted in any sequence rapidly and easily. Total revolution time is determined by motor speed (4 sec per revolution) and the interchangeable gear and rack assembly. Each cam is adjusted for the length of switch closure. A switch is associated with each cam and its closure is controlled by the cam setting. The switches are single pole double throw snap action, U/L and CSA approved, totally enclosed. The switches are mounted on individual brackets, permitting removal of each switch without disassembling the entire switch bank. The switch contacts are rated at 10 amps

non-inductive AC. The motor will maintain 0.5% accuracy for line regulation of 115 VAC ± 10, 60 cps.

The system multiplexer will consist of 8 cams, four of which will be used to multiplex 4 channels of system operating voltage at sampling rates of one second per channel with a fifth cam to provide an identification marker for the first channel. Two (2) cams will be used to multiplex 2 channels of system temperature at sampling rates of one per second with a third cam to provide an identification marker for the first channel.

The identification marker will be a spike leading the first channel of both multiplexed groups. The spikes will be produced by means of microswitch for each identification marker cam which will supply a 28 VDC spike to the record. This marker will also feed the oscillographic recorder event marker for system correlation.

# SECTION III
# INSPECTION AND TEST

## 3.1 GENERAL

During the manufacture of the NCU Checkout Console System, the equipment, components and work (fabrication and assembly) will be coordinated with the purchaser in regard to expediting and inspection thereof.

HED will conduct an operational test prior to shipment of the NCU checkout console system to demonstrate the compliance with the purchaser's requirements.

HED will furnish, at no additional cost, facilities (including office space) and assistance for the safe and convenient inspection and test required by the purchaser in the performance of his duties.

## 3.2 QUALIFICATION ACCEPTANCE TEST AT CONTRACTOR'S FACILITY

Hallamore will conduct the Qualification Acceptance Test as outlined in Paragraph 3.6.1 of Thiokol Specification EIS-8. The test will be scheduled over a two-week period prior to delivery. The test will be conducted and sequenced as follows.

A. No Fault Test

The console unit will be placed into operation, ie., simulated input, calibration etc., and will so function for five days, 24 hours a day. No specific environment will be held for this test.

B. Endurance, Reliability and Accuracy Test

The console unit will be set into the HED environmental chamber, placed into operation, ie., simulated inputs, calibration, etc., then the following test sequence will be performed:

1st Day: Chamber will be brought down to 60°F (chamber tol. = $\pm$ 3°). It will take the chamber about three hours to stabilize. After the unit is on 30-minute endurance test will be performed (50 one-minute runs-breaker on and off). After the chamber has stabilized at 60° $\pm$ 3°, reduce line voltage to 105 VAC and make 50 one-minute runs. Raise voltage to 125 VAC and make 50 one-minute runs.

2nd Day: Chamber will be brought to 80°F (chamber tol. = $\pm$ 3°). It will take the chamber about two hours to stabilize. After the unit is on 30-minute endurance test will be performed (50 one-minute runs-breaker on and off). After the chamber has stabilized at 80° $\pm$ 3°, reduce line voltage to 105 VAC and make 50 one minute runs. Raise voltage to 125 VAC and make 50 one-minute runs. Change time voltage to 120 VAC and perform accuracy test (50 one-minute runs).

3rd Day: Chamber will be brought to 100°F (chamber tol. = $\pm$ 3°). It will take the chamber about two hours to stabilize. After the unit is on 30-minute endurance test will be performed (50 one-minute runs-breaker on and off). After the chamber has stabilized at 100° $\pm$ 3°. Reduce line voltage to 105 VAC and make 50 one-minute runs. Raise voltage to 125 VAC and make 50 one-minute runs.

C. Repeatability and Accuracy Calculation

Data obtained from the preceeding test will be utilized in the formulation of the system calculations of repeatability and accuracy as outlined in paragraph 3.6.1.4.

D. Not included in these acceptance tests is the evaluation of the Christie Electric Corp, Power Supply, 400 Amp @ 30 VDC, in that it is understood by Hallamore that it is an acceptable item to Thiokol.

## 3.3 ACCEPTANCE TEST AT THIOKOL

Hallamore will assign a Field Engineer at Thiokol to conduct the tests required by Thiokol Specification EIS-8, paragraphs 3.6.2 and 3.11.2, and "on call" for 3.13. Hallamore has costed 3.6.2, 3.11.2 and 3.13 requirements on a man week basis, in that 3.6.2 and 3.11.2 requirements are to be defined after award of contract. No material cost is included to perform 3.6.2 requirements.

# SECTION IV
# PROJECT MANAGEMENT

## 4.1 PROJECT TEAM

The Hallamore project team assigned to this task consists of a group headed by a Project Manager supported by Responsible Engineers, their staffs and representatives of all concerned company departments. The Project Manager is directly responsible to the customer and is personally aware of all phases of the entire project. This organizational system assures closer adherence to schedules, lowered costs and increased quality of end products. Figure 4-1 illustrates a project organization which would be used for the proposed task. Figure 4-2 is a preliminary schedule for accomplishment of this project. Following is a description of the functions of the key positions which constitute the Project Team.

### Project Manager

The program will be headed by a Project Manager who will be responsible for the technical and managerial aspects of the complete project. Key departmental personnel assigned to the project will operate under their respective corporate policies, but will report to the Project Manager for all phases of this program.

### Project Engineer

The project will be organized with a Project Engineer, who will report to the Project Manager. An engineering system will be formed for efficient delegation of responsibility. The selection of a Project Engineer will be based on his engineering experience and abilities as well as his administrative ability.

The Project Engineer will coordinate all technical activities with a subsystem group consisting of electronic, mechanical and design engineers and drafting

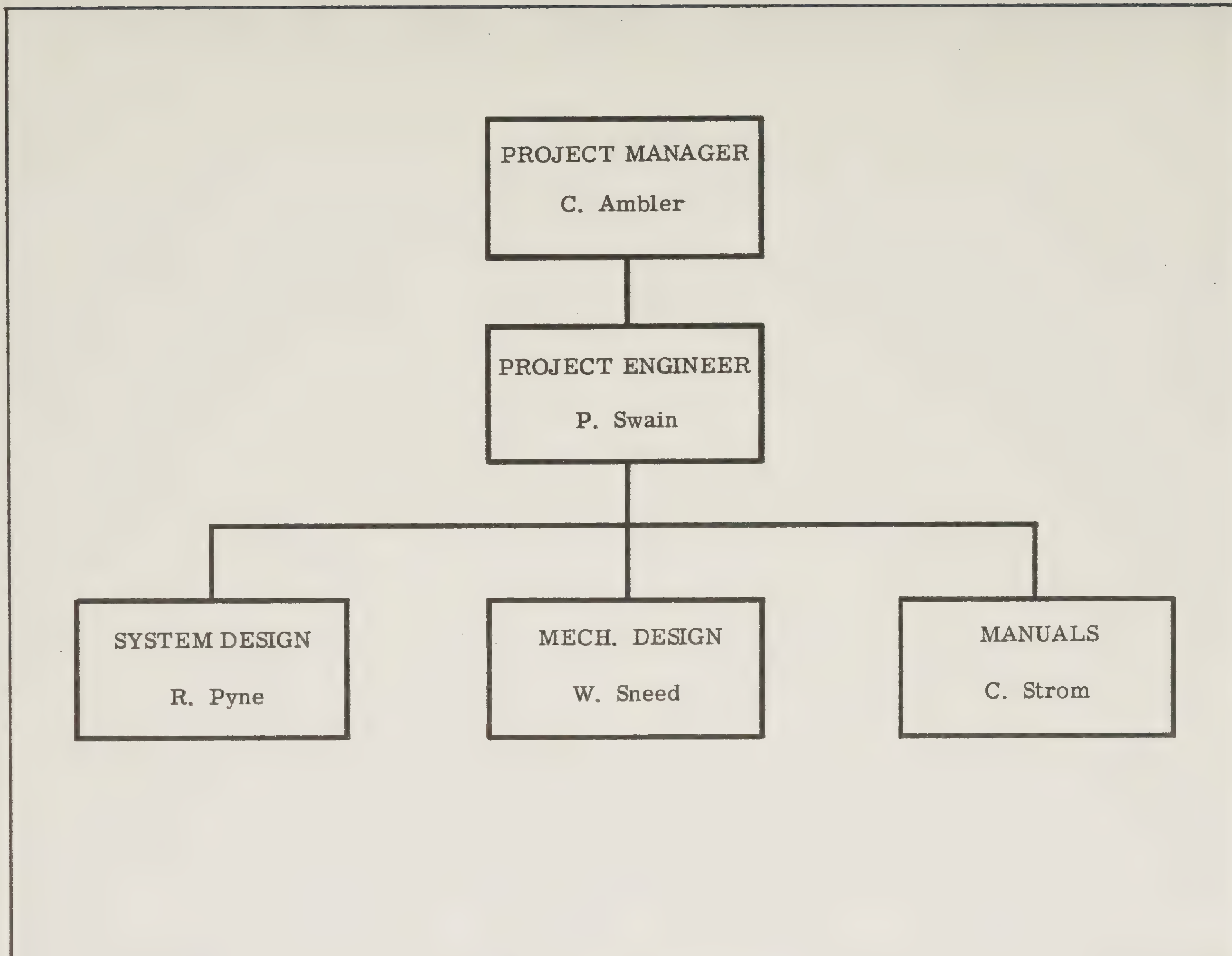



Figure 4-1. Project Organization

and checking services; perform first level personnel supervision; provide technical guidance for personnel within this group; provide detail technical guidance for the procurement of materials, project planning and scheduling, Contracts Administration, Budget Control, and Quality Control.

Field Liaison

The Hallamore Electronics Division will, whenever necessary, establish at or near the customer's facility, personnel for field liaison. Initially, the Project Engineer and Responsible Engineer will act in this capacity.

## 4.2 PROJECT SUPPORT

Procurement

A procurement group, directed by the Project Manager, will handle material activities. The personnel comprising this group will be selected on the basis of their material procurement experience. They will be responsible to procure all equipment and will in addition determine, in coordination with the Project Engineer, those common items which should be produced for the entire project to maintain uniformity of standard electronic equipment and to reduce maintenance and spares requirements.

Planning and Scheduling

The Master Planning and Scheduling Group of Hallamore will assign personnel to be responsible to the Project Manager for master planning and establishment of detailed schedules for each phase of this task. This group will provide necessary reports to all parties showing progress as it relates to contract schedule, and reflecting estimated completion dates of each major phase of the program.

Contracts Administration

A project Contract Administrator will be assigned to administer the entire project from a contractual viewpoint only. He will be responsible for assuring

operation within contractual requirements and coordination of mutual problems and requests.

Budget Control

Hallamore will assign a Budget Analyst who will be responsible for the establishment of detail budgets with the contractual amount for each portion of the project. He will be responsible for providing such reports as are deemed necessary, showing performance to the budget allocation.

Quality Control and Inspection

Quality Control will be maintained over incoming material, fabrication, and production testing. Records of all inspection work and tests, which are conducted to determine compliance with the technical requirements of applicable specifications, will be kept complete and will be available for inspection at all times.

Fabrication and Assembly

The Hallamore Production Department will assign the necessary skilled craftsmen and technicians to the Project Team for all fabrication and assembly work. The personnel comprising this group will be selected on the basis of their past experience and capabilities on this type of equipment. At present, the Hallamore Production Department has numerous personnel that have had considerable experience in X-Band equipment.

Standards Laboratory

The Hallamore Standards Laboratory will assign the necessary engineers and technicians to the Project Team on an "as required" basis for all equipment calibration. The personnel comprising this group will be selected on the basis of their past experience and capabilities on this type of equipment.

Environmental Laboratory

Facilities and personnel in the Environmental Laboratory will be available for the project.

Publications

The Hallamore Publications Department will assign the necessary technical writers and illustrators to the Project Team for all manual and report assignments. The personnel comprising this group will be selected on the basis of their past experience in this field.

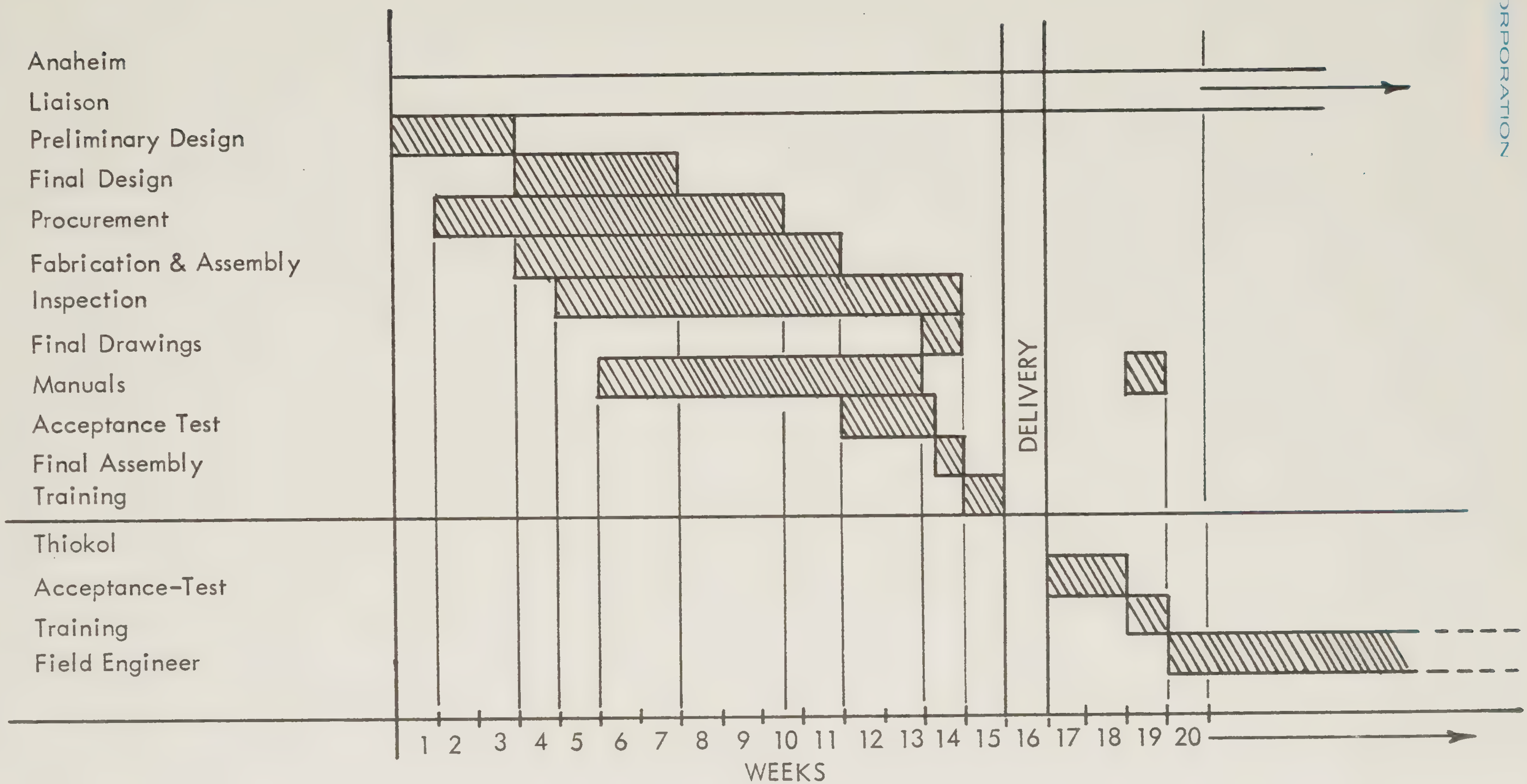



Figure 4-2. Schedule

The following resumes have been purposes omitted from this copy of the proposal:

C. Ambler

P. Swain

R. Pyne

R. Fried

W. Sneed

D. Balfour